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The relations between north Atlantic oscillation and minimum temperature in Turkey

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Abstract

It has been observed that there is a significant negative correlation between the average temperature values taken from the 32 stations chosen across Turkey and the North Atlantic Oscillation. However, more interestingly the reaction of the stations to the North Atlantic Oscillation and the degree of the significance of the correlations become weaker as we move in a west-east direction. The factors of continentality-oceanity have also obvious effects on the correlation values. This effect is more clearly seen between the temperature values and the atmospheric oscillations. The North Atlantic Oscillation is particularly effective on the temperatures from the stations located in areas where continental climate prevails. On the other hand, this effect is either too weak or gives an insignificant correlation in the stations located in areas where maritime climate prevails.

There isn't a significant correlation between the temperature values from the stations that are in lower longitudes and the North Atlantic Oscillation. When we take the negative years into account separately from a statistical standpoint, we see that there is a more significant correlation between the North Atlantic Oscillation and the temperature values than that of the positive years. Generally there is a negative correlation between the minimum temperature values of the stations and the index value in those years in which the North Atlantic Oscillation index values are negative. In other words, as the index values of the North Atlantic Oscillation decrease, the minimum temperatures in Turkey increase. The reason for this can be said to be the westerly winds carry a great amount of humid and warm air masses to the Mediterranean basin and make the climate there milder.

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1. Introduction

The Earth's climate system has a very delicate and fragile structure. It has been approximately 4,5 billion years since the formation of the Earth. The Earth has been subject to a number of gradual changes within this period and it is still subject to such changes. These changes that our world has experienced and is still experiencing have been classified into geological times and a geological time chart has been created by means of combining these geological times. When these geological periods have been examined, it has been identified with the help of the findings of scientific studies that significant changes and oscillations have occurred in the Earth's climate system. The results of these studies demonstrate that the leading factor that has the most significant impact on the Earth's climate system in general is the solar activities. After this factor, the most influential component and factor on the climate is the ocean-current system. Particularly, as a consequence of the studies they have carried out within the last quarter of the 20th century, climatologists have found out that the ocean current system is much more influential on the climate system than it was previously thought. These current systems make a number of oscillations with the wind systems and the most popular of these is the el nino-la nina, which is also called southern oscillation. Later in the 21st century, it has been suggested that not only the southern oscillations, but particularly certain changes in the North Atlantic with regard to determining the climatic conditions in the northern hemisphere have impact on the climate system; in fact, as a result of the studies carried out, it has been discovered that the Mediterranean Basin, the northeast of North America and principally the European continent are affected by this oscillation. This oscillation has been named as the North Atlantic Oscillation. The studies conducted later were focused on the Arctic Oscillation, which also has a great impact on the climate system as well as the abovementioned oscillations.

Some climate elements such as temperature, pressure and precipitation show changes each year depending on the changes in the atmospheric circulation in the Earth and some relations have been identified between the regions that have been thought to be different in terms of these climatic parameters.

Simultaneous changes in spots distributed across a wide area in the world have long been recorded in meteorology literature (Hurrel, 2003). These simultaneous changes are generally called Teleconnection, or large-scale connection. In addition to this, while temperatures in a particular part of the world are below the seasonal averages from time to time, in another part of the world, milder conditions prevail. One of the large-scale connection models that have impact on the temperate and high latitudes in the Northern Hemisphere is the North Atlantic Oscillation. The North Atlantic Oscillation affects a region from the north-eastern coasts to the Siberian region and similarly from the Arctic region to the subtropical Atlantic region (Hurrel, Kushnir, Visbeck, 2001).

On the other hand, the North Atlantic Oscillation is also called regional reflection of the large-scale (hemispheric) form of the variability known as the Arctic Oscillation (Hurrel, 2003). The most important point to pay attention at this point is that the effect of The Arctic Oscillation on the North Atlantic Oscillation is undeniably great.

2. Material and Method

2.1. Data Collection Techniques

In this study, the minimum temperature data of the years from 1975 to 2012 belonging to 32 stations which have been chosen for sampling in Turkey have been used. Afterwards, annual average temperature values have been calculated on the basis of these data. When the stations were being chosen, some important points were taken into consideration. In order to identify the variations that might occur in the temperature values more clearly, the stations were intentionally chosen in the east-west direction and also north –south direction of Turkey. We have aimed at determining the relation between the temperature and precipitation data from the stations and the North Atlantic Oscillation, taking the North Atlantic Oscillation and the air masses that affect Turkey and the geographical surface features as well as the oceanity - continentality into consideration.

The index values of the North Atlantic Oscillation have been obtained from National Oceanic and Atmospheric Research Centre. In order to be able to relate these index values to the temperature data from the 32 stations chosen in Turkey, the data have been selected from the same period of time (1975-2012). Then, the relation between the North Atlantic Oscillation and the minimum temperatures by their location and by correlation analysis.

Correlation analysis is one of the statistical methods which is used to determine the value and direction of the relation between two variables. Whether the variables are dependant or independent isn't taken into account. There are different correlation coefficients that is calculated in a different way and used for different purposes such as Pearson Correlation coefficient, Canonical Correlation Coefficient and partial correlation coefficient. Among these, Pearson is represented by correlation coefficient r and it is calculated by means of its formulae (Orhunbilge, 1996).

The correlation coefficient value can vary between -1 and $+1$ ($-1 \leq r \leq +1$). The coefficient is 0 when there is no relation between, $+1$ if there is a strong relation in the form of an absolute and simultaneous rise or fall or -1 if there is an absolute and reverse relation. In the evaluation of the level of relation between the variables, it isn't important for the coefficient obtained to be positive or negative; rather, the absolute value of the given value should be taken into consideration. The level of relation between the coefficients is low if the correlation coefficient is between 0 and $0,25$; medium if the coefficient is between $0,50$ and $0,69$ and high if the coefficient is between $0,70$ and $0,89$ and very high is the value is between $0,90$ and 1 . The correlation coefficient is calculated by the following equation, where r is the correlation coefficient, n is the number of observations and x and y are the values to be correlated (Çömlekçi, 1989; Orhunbilge, 1996; Kadılar 2005).

$$r = \frac{\sum_{i=1}^n x_i y_i - n \bar{x} \bar{y}}{\sqrt{\left(\sum_{i=1}^n x_i^2 - n(\bar{x})^2 \right) \left(\sum_{i=1}^n y_i^2 - n(\bar{y})^2 \right)}}$$

In this equation, X value represents the index values of the North Atlantic Oscillation and the Y variable represents the minimum temperature value. Minimum temperature values and the index values belonging to the North Atlantic Oscillation in negative and positive years have been separately analysed and the following equation has been used in either analysis:

$$\bar{x} = \frac{\sum_{i=1}^n x_i}{n} \quad \text{and} \quad \bar{y} = \frac{\sum_{i=1}^n y_i}{n}$$

Furthermore,

Afterwards, tables have been formulated through these correlation calculations and general tendency and significance tables have been obtained. While formulating these tables, by using colouring method, it has been investigated what kind of a relation there is between the stations and the atmospheric oscillations. Maps of correlation tendency and significance have been drawn. In order for the analysis results to be seen more clearly on the map and to be better understood, the stations that demonstrate insignificant negative tendency have only been marked with a negative sign in a shade of blue as well as the colouring method and such stations have been positioned on the map with the help of GIS.

The stations that show a positive tendency have been marked with a positive sign in shades of red and they, too, were positioned on the map by using GIS method. So that we can better illustrate the levels of correlation significance, negative years and positive years have been assessed separately.

3. The analysis of general tendency maps of the north Atlantic oscillation on the basis of negative years and minimum temperature data from certain stations chosen in Turkey

It has been observed that there is generally a negative correlation between the North Atlantic Oscillation on the basis of negative years and the minimum temperatures between the years that belong to the stations (Fig.1). The results of the analysis show that the highest correlations in terms of significance are in the cities of Afyonkarahisar, İzmir, Konya, Kırşehir and Gaziantep. Afyonkarahisar emerges as one of the few cities in Turkey, where there is a significant negative correlation between the minimum temperature values on the basis of negative years and the North Atlantic Oscillation index values. After Afyonkarahisar, the station in İzmir follows. The other stations in descending order are Gaziantep, Kırşehir and Edirne. Similarly, there is a significant negative correlation between the minimum temperature values that were taken from the station in Konya and the North Atlantic Oscillation index

values. The other stations also generally show a negative correlation with the North Atlantic Oscillation. Of these 32 stations that were chosen in Turkey, the ones that have the weakest negative correlation between the North Atlantic Oscillation and the minimum temperature values are as follows: There is an insignificant negative correlation between the minimum temperature values taken from the station in Erzurum and the North Atlantic Oscillation index values. The station in Sivas follows the one in Erzurum. The other stations that show weak negative correlation between the minimum temperatures and the North Atlantic Oscillation are in the provincial centres of Van, Adana, Malatya, Elazığ, Siirt, Muğla, Tokat, Bursa and Trabzon. Generally speaking, the effects of the North Atlantic Oscillation on the minimum temperatures can be more clearly seen in particularly the western parts of Turkey, but they become even clearer in those stations where the effects of continentality is dominant. In fact, Afyonkarahisar, Konya and Isparta verify this thesis. However, although the station in Erzurum, which is the easternmost, demonstrates harsh continentality features, it doesn't show the effects of the North Atlantic Oscillation on the minimum temperatures. Similarly, Bursa, which is on the west but doesn't show continentality features, demonstrates weak effects of the North Atlantic Oscillation on the minimum temperatures. When we look in general at the effects of the North Atlantic Oscillation on the minimum temperature values on the basis of negative years, the general tendency is towards negative correlation in Fig. 1. If we are to handle the subject in terms of significance, we see that the stations in the east of Turkey generally show insignificant correlations, while the ones in the west are observed to show significant negative correlations. The general condition of correlation is clearly seen in Fig. 1.



Fig. 1. The relation between the North Atlantic Oscillation and the minimum temperature values on the basis of negative years.

4. The analysis of general tendency maps of the north Atlantic oscillation on the basis of positive years and minimum temperature data from certain stations chosen in Turkey

When the effects of the North Atlantic Oscillation on the minimum temperatures from the chosen stations are compared with the reactions of the minimum temperatures on the basis of the negative years to the North Atlantic Oscillation, we see that they show different reactions. While the stations in the west show a positive correlation with the North Atlantic Oscillation, as we move eastward, this tendency is reversed into a negative correlation. Whereas İzmir, which is the westernmost, shows a positive correlation, as we move eastward, the level of positive correlation decreases and it is reversed in Malatya. Similarly, the station in Kırklareli, which is westernmost, show a significant

positive correlation, while the stations in Florya and Kireçburnu have been found out to show a positive correlation, though at a weaker level of significance. On the other hand, it is observed that there is a negative correlation between the minimum temperatures in Çorum, which is located in Mid-Black Sea Region and the North Atlantic Oscillation.

It has been observed that there is generally a positive correlation between the minimum temperature values and the North Atlantic Oscillation index values in the west of Turkey, while there is a negative correlation in the east. It can be derived from the results of the analysis that as the North Atlantic Oscillation index values increase, the minimum temperature values in the stations in the west of Turkey also increase; however, the minimum temperature levels in the stations in the east of Turkey decrease in the same case. In this case, the effects of the North Atlantic Oscillation are widespread, yet there are other prevalent atmospheric systems in the east, thus weakening the effects of the North Atlantic Oscillation. Furthermore, it has been found out that the effects of the North Atlantic Oscillation in Turkey on the whole are weaker on the basis of positive years.

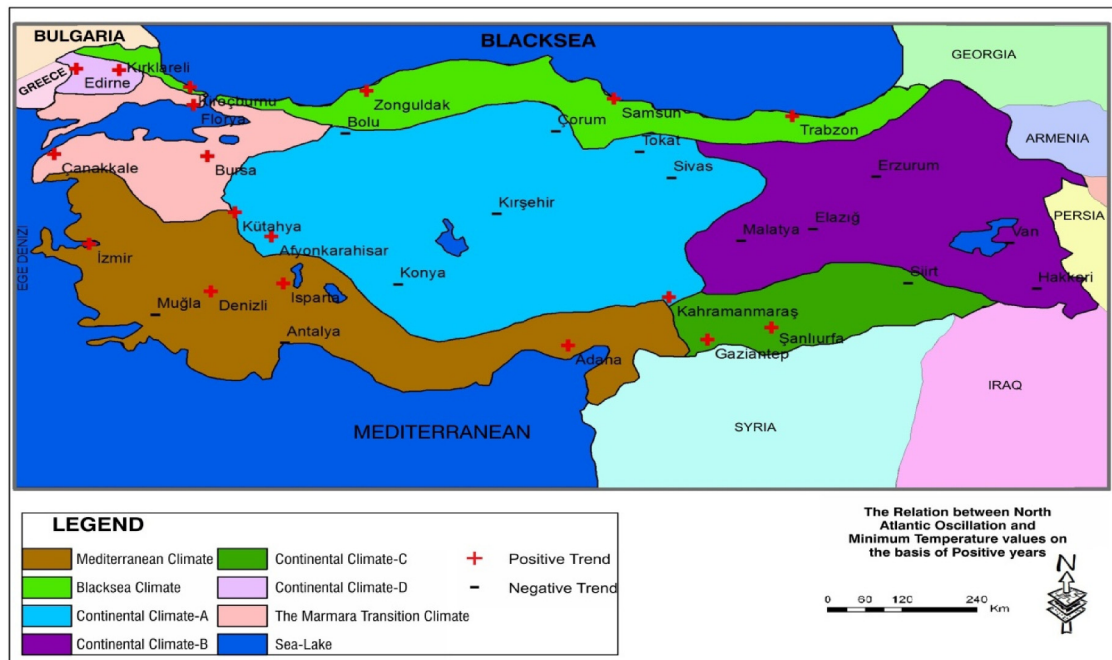


Fig. 2. The relation between the North Atlantic Oscillation and the minimum temperature values on the basis of positive years.

5. Conclusion

One of the most important components of the Earth's Climate System is the atmospheric oscillations that occur depending on the ocean-atmosphere system. The North Atlantic Oscillation is the most important one among these atmospheric oscillations in the Northern Hemisphere in that it particularly affects the north and the east of USA, Greenland, the European continent and the Mediterranean basin.

It can be observed that there is a generally significant negative correlation between the average temperature values from the chosen 32 stations in Turkey and the North Atlantic Oscillation. However, the most striking point here is that as we move from west to east, the reaction of the stations to the North Atlantic Oscillation gets weaker and the level of significance of the correlation decreases.

Another important conclusion to be drawn is that oceanity - continentality obviously affects the correlation values. This effect is particularly observed clearly between the temperature values and the atmospheric oscillations. The North Atlantic Oscillation is especially influential on the temperatures at the stations where continental climate

prevails. In contrast, at the stations where an oceanic climate prevails, this effect is either too weak or creates an insignificant correlation.

Another important conclusion to be drawn from this study is that there aren't any significant correlation values between the temperature values from the stations which are on lower longitudes and the North Atlantic Oscillation. For instance, the reactions of the station in Adana to both North Atlantic Oscillation and the Arctic Oscillation are weakly significant. Similarly, the stations in Şanlıurfa, Gaziantep, Kahramanmaraş, Muğla, Antalya and Denizli show extremely weak significance or some correlation levels that can be said to be insignificant.

One of the most important conclusions is that when the negative years are evaluated separately from the other factors, there are more significant correlation levels between the North Atlantic Oscillation and the minimum temperature levels than those of the positive years. Generally, in those years when the North Atlantic Oscillation index values are negative, there is a negative correlation between the minimum temperature levels at the stations and the index values. In other words, as the North Atlantic index values decrease, the minimum temperatures in Turkey tend to increase. The reason for that is likely to be the western wind zones that carry great amounts of humid and warm air masses to the Mediterranean Basin and thus moderating the climate.

In conclusion, the North Atlantic Oscillation is a very important component of the Earth climate system. In addition, we must not overlook the Sun's activities, which are the most important element of the Earth climate system which is composed of all these important components. Unfortunately, today ocean-atmosphere oscillations are overlooked as a result of the debates of global warming and global climate changes and human factor comes into prominence.

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